

## IMAGE READING APPARATUS

### BACKGROUND OF THE INVENTION

#### Field of the Invention

5           The present invention relates to an image reading apparatus, and particularly to an image reading apparatus provided with an original illuminating system in which light source portions (illuminating light sources) for illuminating an  
10 original, such as a document, are disposed on both sides of an optical axis of an image forming unit.

#### Related Background Art

          In an original illuminating system of a conventional image reading apparatus, two light  
15 source portions 23 and 24 for illuminating an original are disposed on both sides of an optical axis S of an image forming lens 28 as illustrated in Fig. 3, for example. Those light source portions 23 and 24 are comprised of elongate fluorescent lamps,  
20 xenon lamps, LED arrays, or the like, respectively, and illuminate image information of an original 21, such as a document, placed on an object table glass 22 from both sides of the optical axis S when turned on simultaneously.

25           Optical path of light reflected by the illuminated original 21 is deflected by first, second and third reflective mirrors 25, 26 and 27 in an

apparatus body. The light is imaged on a solid pick-up device 29, such as a CCD, by the image forming lens 28, and the image information of the original is read in a tow-dimensional manner.

5           A principal reason for using two light source portions 23 and 24 as the original illuminating system as discussed above is that the amount of illumination light for illuminating the original 21 needs to be increased. Even in a conventional  
10 original illuminating system including a single light source portion, the amount of illumination light can be increased by arranging a reflecting portion at a location facing the light source portion. It is, however, difficult to increase the amount of  
15 illumination light up to such a level as is equal to that of the original illuminating system including two light source portions which are to be simultaneously lighted.

          The amount of light reflected by the original  
20 21 increases as the amount of illumination light increases, and the amount of light of the original image formed on the solid pick-up device 29, such as the CCD, is accordingly increased. Resultantly, its output signal is increased, and noise of the image  
25 information is hence reduced. It is thus possible to read the image information with higher image quality.

          The original illuminating system used in the

conventional image reading apparatus as illustrated in Fig. 3, however, has the following disadvantage.

Although conventionally not described clearly, two light source portions 23 and 24 are normally  
5 disposed at optimal locations in the light of a space given to the original illuminating system, respectively. Therefore, those light source portions are disposed at symmetrical locations with respect to the optical axis S of the image forming lens 28 as  
10 illustrated in Fig. 3.

However, when the two light source portions 23 and 24 are disposed at symmetrical locations with respect to the optical axis S as illustrated in Fig. 3, the following phenomenon occurs. Illumination  
15 light N of the original 21 from one light source portion 23 is diffused and reflected by the original 21. Since the other light source portion 24 is disposed at a location in a path along a specular or regular reflection direction of that reflected light,  
20 a strong reflective component L of the reflected light enters an opening portion 24a of the light source portion 24. This incident light is diffused in the light source portion 24, and diffused light M once again illuminates the original 21. Accordingly,  
25 image information is degraded due to the density of the original 21, and so-called reflective illumination is thus increased. This phenomenon

holds with respect to the other light source portion  
24.

The above-discussed reflective illumination is  
the phenomenon in which light for illuminating an  
5 original is diffused by the original which normally  
has a diffusing surface, and the diffused light is  
returned to the original illuminating system, and  
once again illuminates the original (see Japanese  
Patent Application Laid-Open No. 7-23226, for  
10 example).

Therefore, the reflectance (density) of the  
original is influenced by the reflectance of itself  
(the original). This influence can be expressed by  
the fact that the output S of the solid pick-up  
15 device, such as the CCD, is not only proportional to  
the reflectance R of the original, but also  
influenced by higher order factors of the reflectance  
R, which is written as

$$S \propto R + \alpha R^2 + \beta R^3 + \dots$$

20 Thus, the signal of the reflectance R is  
adversely influenced by unwanted components, and it  
is difficult to obtain accurate information of the  
reflectance (density) of the original. Accordingly,  
the original illuminating system is required to have  
25 such a structure that the reflective illumination  
component can be reduced as much as possible.

However, when two light source portions 23 and

24 of the original illuminating system are disposed symmetrically with respect to the optical axis S of the image forming lens 28 as discussed above, the reflective illumination component increases since a strong specular reflection component of the illumination light for the original form one of the light source portions enters the other light source portion. Hence, reading precision of image information of the original is likely to lower.

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#### SUMMARY OF THE INVENTION

It is an original of the present invention to provide an image reading apparatus in which the amount of illumination light is increased and at the same time adverse influence of reflective illumination is reduced, and which is capable of reading image information of an original with high precision.

According to one aspect of the present invention, there is provided an image reading apparatus which includes an illuminating unit for illuminating image information of an original placed on an original support, and an image forming unit for imaging the image information on a reading unit. In the image reading apparatus, the illuminating unit includes a plurality of light source portions, the image information is read in a two-dimensional manner

by changing a relative position between the image  
information and the reading unit, and the plurality  
of light source portions are disposed asymmetrically  
with respect to an optical axis of the image forming  
5 unit in a sub-scanning cross-sectional plane.

Based on the above fundamental construction of  
the image reading apparatus, the following more  
specific structures can be used.

The plurality of light source portions can be  
10 adapted to be simultaneously lighted, and illuminate  
the image information.

The plurality of light source portions can have  
the same shape or/and the same illumination  
characteristics.

15 According to another aspect of the present  
invention, there is provided an image reading  
apparatus which includes an illuminating unit for  
illuminating image information of an original placed  
on an original support, and an image forming unit for  
20 imaging the image information on a reading unit. In  
the image reading apparatus, the illuminating unit  
includes a plurality of light source portions, and a  
plurality of reflective portions provided  
corresponding to the plurality of light source  
25 portions and adapted to reflect light from the light  
source portions toward a side of the image  
information, respectively, the image information is

read in a two-dimensional manner by changing a relative position between the image information and the reading unit, and the plurality of reflective portions are disposed asymmetrically with respect to  
5 an optical axis of the image forming unit in a sub-scanning cross-sectional plane.

Also based on the above fundamental construction of the image reading apparatus, the following more specific structures can be used.

10 The plurality of light source portions can be disposed asymmetrically with respect to the optical axis of the image forming unit in the sub-scanning cross-sectional plane.

The plurality of light source portions can be  
15 adapted to be simultaneously lighted, and illuminate the image information.

The plurality of light source portions can have the same shape or/and the same illumination characteristics.

20 The plurality of reflective portions can have mutually different shapes.

These and further aspects and features of the invention will become apparent from the following detailed description of preferred embodiments thereof  
25 in conjunction with the accompanying drawings.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic view illustrating a main portion of an image reading apparatus of a first embodiment according to the present invention;

Fig. 2 is a schematic view illustrating a main  
5 portion of an image reading apparatus of a second embodiment according to the present invention;

Fig. 3 is a schematic view illustrating a conventional image reading apparatus; and

Fig. 4 is a schematic view illustrating a main  
10 portion of an image reading apparatus according to the present invention.

#### DESCRIPTION OF THE PREFERRED EMBODIMENTS

##### (First embodiment)

15 Fig. 1 is a schematic view illustrating a main portion of an image reading apparatus of a first embodiment according to the present invention. In Fig. 1, reference numeral 2 designates an original support (an original object table glass), and image  
20 information of an original 1 is placed on the support 1. Reference numerals 3 and 4 designate light source portions (illuminating light sources) serving as illuminating units, respectively. Each of the light source portions 3 and 4 is comprised of an elongate  
25 fluorescent lamp, a xenon lamp, an LED array, or the like. Those light source portions 3 and 4 are disposed at asymmetrical locations with respect to

the optical axis S of an imaging unit 8 (described later) in a sub-scanning cross-sectional plane. Those two light source portions 3 and 4 have the same shape or/and the same illumination characteristics.

5 The illumination characteristics mean spectral characteristics, luminance characteristics, radiation distribution characteristics, and the like. In the first embodiment, the light source portions 3 and 4 illuminate image information of the original 1 from  
10 both sides of the optical axis S when lighted simultaneously.

Reference numerals 5, 6 and 7 designate first, second and third reflective mirrors, respectively, and these reflective mirrors 5, 6 and 7 deflect the  
15 optical path of light from the original 1 in an apparatus body. Reference numeral 8 designates an image forming lens (a lens for reading the original 1) serving as the imaging unit, and the image forming lens 8 images light, which is created based on the  
20 image information of the original 1, on the surface of a reading unit 9. Reference numeral 9 designates a line sensor (CCD) serving as the reading unit, and the line sensor 9 reads image information in a two-dimensional manner when the relative position between  
25 the line sensor 9 and the image information of the original 1 is changed.

In the first embodiment, the image information

of the original 1 is illuminated from both sides of the optical axis S by simultaneously-radiated light from the two light source portions 3 and 4, and the optical path of light reflected by the illuminated  
5 original 1 is deflected by the first, second and third reflective mirrors 5, 6 and 7 in the apparatus body. The light is imaged on the surface of the CCD 9 by the image forming lens 8. The image information of the original 1 is read in a tow-dimensional manner  
10 when scanning in a main scanning direction is electrically performed while the first, second and third reflective mirrors 5, 6 and 7 are moved in the sub-scanning direction. Here, the distance between the original 1 and the CCD 9 remains unchanged by  
15 moving the second and third reflective mirrors 6 and 7 by a half of the moving amount of the first reflective mirrors 5.

In the first embodiment, the light source portions 3 and 4 are disposed such that the position  
20 of the light source portion 4 is away from a path along a specular reflection  $\theta$  direction relative to an incident angle  $\theta$  on the original 1 of illumination light A illuminating the original 1 through an opening portion 3a of the light source portion 3.  
25 Accordingly, reflection light B of a weak reflective component, but not reflection light D of a strong reflective component reflected in the specular

reflection  $\theta$  direction by the original 1, enters an opening portion 4a of the light source portion 4. This incident light is diffused in the light source portion 4, and light C of the diffused light  
5 illuminates the original 1 once again. Therefore, the amount of light influencing the reflective illumination can be reduced.

It is likewise possible to reduce the amount of light influencing the reflective illumination since  
10 the light source portion 3 is not located in a path along a specular reflection  $\theta$  direction of illumination light for illuminating the original 1 from the light source portion 4.

Further, in the first embodiment, it is  
15 possible to reduce a component which once enters the other light source portion from one light source portion and then illuminates the original 1 once again. Accordingly, it is also possible to reduce light which again enters the one light source portion  
20 and becomes a reflective illumination component, and hence adverse influence of the reflective illumination can be further reduced.

Further, in the first embodiment, two light source portions 3 and 4 are simultaneously lighted as  
25 discussed above to increase the amount of illumination light, and at the same time the reflective illumination is reduced. Image

information of the original 1 is thus read with high precision.

Furthermore, in the first embodiment, one central angle  $\theta$  of light from one of the light source portions illuminating the original 1 is set to be in a range of smaller acute angles (from 10 degrees to 25 degrees), and the other central angle  $\phi$  is set to be in a range of larger acute angles (from 20 degrees to 50 degrees). In other words, one light source portion 3 illuminates the original 1 at smaller acute angles, and the other light source portion 4 illuminates the original 1 at larger acute angles. Accordingly, the other light source portion 4 is positioned relatively away from the optical axis S, and tends to increase the space of the illuminating system, while the one light source portion 3 is positioned relatively close to the optical axis S, and tends to decrease the space of the illuminating system. Therefore, the first embodiment can be constructed substantially without increasing the overall space of the original illuminating system.

In the first embodiment, the light source portions 3 and 4 illuminate the original 1 at smaller acute angles and at larger acute angles, respectively, but this arrangement can be reversed.

Further, in such a kind of image reading apparatus, a case where the original 1, such as a

curled paper, may slightly lift from the object table glass 2 due to a weak hold-down force can occur. In the first embodiment, a decrease in the amount of illumination light due to such lift of the paper can  
5 be suppressed since one central angle  $\theta$  of light for illuminating the original 1 is set to be in the range of smaller acute angles.

Further, since the other central angle  $\phi$  of light for illuminating the original 1 is set to be in  
10 the range of larger acute angles, an original illumination distribution in the sub-scanning direction is widened on the object table glass 2. Accordingly, it is possible to reduce variations in the amount of illumination light due to errors in the  
15 sub-scanning direction caused by deviation in a reading position of the CCD or the like.

As described in the foregoing, in the first embodiment, two light source portions 3 and 4 are asymmetrically disposed with respect to the optical  
20 axis S, and are arranged such that the position of each light source portion is deviated from the path along the specular reflection  $\theta$  direction (a direction in which illumination light is strongly reflected) of illumination light from the other light  
25 source portion. Accordingly, the amount of illumination light can be increased, and at the same time adverse influence of the reflective illumination

can be reduced. Image information of the original 1  
can hence be read with high precision.

Although two light source portions 3 and 4 are  
asymmetrically disposed with respect to the optical  
5 axis S in the first embodiment, the number of light  
source portions can be more than two. For example,  
in the case of three light source portions, it is  
possible to dispose one light source portion on one  
side of the optical axis S, and dispose two light  
10 source portions asymmetrically relative thereto.

Further, the first embodiment is directed to  
the image reading apparatus having a 1:2 scanning  
optical system, but the present invention can also be  
applied to an image reading apparatus of a united  
15 unit type (a flat bed type) as illustrated in Fig. 4,  
for example, with the same effect as that of the  
first embodiment.

In Fig. 4, image information of an original 51  
is illuminated by simultaneously-radiated light from  
20 two light source portions 3 and 4, and the optical  
path of light reflected by the illuminated original  
51 is deflected by first, second, third and fourth  
reflective mirrors 55, 56, 57 and 58 in a carriage 61.  
The light is imaged on the surface of a linear image  
25 sensor 60, such as a linear CCD, by an image forming  
lens 59. The image information of the original 51 is  
read in a tow-dimensional manner by moving the

carriage 61 in a direction (the sub-scanning direction) of arrow R illustrated in Fig. 4 using a sub-scanning motor (not shown). Here, the linear CCD 60 is comprised of a plurality of light receiving elements arranged linearly (in the main scanning direction).

(Second embodiment)

Fig. 2 is a schematic view illustrating a main portion of an image reading apparatus of a second embodiment according to the present invention. In Fig. 2, the same reference numerals as those of Fig. 1 designate the same elements as those of Fig. 1, respectively.

The second embodiment is different from the above-discussed first embodiment only in that reflective portions 15 and 16 are provided correspondingly to light source portions 13 and 14 to reflect light from the light source portions 13 and 14 toward the side of image information, and not only light source portions 13 and 14 but also reflective portions 15 and 16 are disposed at asymmetrical locations with respect to the optical axis S of an image forming lens 8 in the sub-scanning cross-sectional plane, respectively. Other structure and optical operation of the second embodiment are approximately the same as those of the first embodiment, and the same technical advantages are

likewise achieved.

In the second embodiment, each of the two light source portions 13 and 14 is comprised of an elongate illuminating light source with a small diameter and without an opening portion, such as a cold cathode-ray tube, and the reflective portions 15 and 16 are provided partially surrounding the light source portions 13 and 14 to increase the amount of illumination light, respectively. In the second embodiment, the light source portions 13 and 14 and the reflective portions 15 and 16 are disposed at asymmetrical locations with respect to the optical axis S of the image forming lens 8 in the sub-scanning cross-sectional plane, respectively. Each of the reflective portions 15 and 16 of this embodiment is comprised of a concave mirror, an aspherical reflective mirror, or the like.

In the second embodiment, simultaneously-radiated light from the two light source portions 13 and 14 directly illuminate the original 1, and light from the light source portions 13 and 14 can also illuminate the original 1 through the reflective portions 15 and 16, respectively. Therefore, the amount of illumination light is further increased as compared with the first embodiment.

In the second embodiment, the light source portions 13 and 14 and the reflective portions 15 and

16 are disposed such that the position of the light source portion 14 and light illuminating the original 1 from the side of the reflective portion 16 are away from a path along a specular reflection  $\alpha$  direction relative to an incident angle  $\alpha$  on the original 1 of illumination light X from the light source portion 13 and the side of the reflective portion 15. Accordingly, reflection light Y of a weak reflective component, but not reflection light W of a strong reflective component reflected in the specular reflection  $\alpha$  direction by the original 1, enters the light source portion 14 and the side of the reflective portion 16. This incident light is diffused, and light Z of the diffused light illuminates the original 1 once again. Therefore, the amount of light influencing the reflective illumination can be reduced.

It is likewise possible to reduce the amount of light influencing the reflective illumination since the light source portion 13 and the reflective portion 15 are not positioned in a path along a specular reflection direction of illumination light illuminating the original 1 from the light source portion 14 and the side of the reflective portion 16.

Further, in the second embodiment, it is possible to reduce a component which once enters the other light source portion and the side of the other

reflective portion from one light source portion and one reflective portion and then illuminates the original 1 once again. Accordingly, it is also possible to reduce light which again enters the one  
5 light source portion and the side of the one reflective portion, and becomes a reflective illumination component, and hence adverse influence of the reflective illumination can be further reduced.

Further, in the second embodiment, two light  
10 source portions 13 and 14 are simultaneously lighted, the reflective portions 15 and 16 are used as discussed above to increase the amount of illumination light, and at the same time the reflective illumination is reduced. Image  
15 information of the original 1 is thus read with high precision.

Furthermore, in the second embodiment, illumination directions of the two reflective portions 15 and 16 corresponding to the two light  
20 source portions 13 and 14 are optimized according to the respective light source portions to increase the amount of illumination light, but the optimized arrangement is not limited thereto. For example, it is possible to independently optimize directions and  
25 shapes of the reflective portions according to the asymmetrical locations of the light source portions with respect to the optical axis to increase the

amount of illumination light.

As described in the foregoing, in the second embodiment, the reflective portions 15 and 16 as well as the light source portions 13 and 14 are  
5 asymmetrically disposed with respect to the optical axis S. Accordingly, the amount of illumination light can be increased, and at the same time the influence of the reflective illumination can be reduced. Image information of the original 1 can  
10 hence be read with high precision.

Although both the light source portions 13 and 14 and the reflective portions 15 and 16 are asymmetrically disposed with respect to the optical axis S in the second embodiment, only the light  
15 source portions 13 and 14, or the reflective portions 15 and 16 can be asymmetrically disposed.

As described in the foregoing, according to the present invention, plural light source portions (and/or reflective portions) are asymmetrically  
20 disposed with respect to the optical axis of the image forming unit in the sub-scanning cross-sectional plane. Accordingly, the amount of illumination light can be increased, and at the same time the influence of the reflective illumination can  
25 be reduced. Hence, it is possible to provide image reading apparatuses in which image information of an original can be read with high precision.

While the present invention has been described with reference to what are presently considered to be the preferred embodiments, it is to be understood that the invention is not limited to the disclosed  
5 embodiments. On the contrary, the invention is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims. The scope of the following claims is to be accorded the broadest  
10 interpretation so as to encompass all such modifications and equivalent structures and functions.